

Learning Python

Getting results for beamlines and scientific programming

2. Basic Python: higher level data types

The Advanced Photon Source is an Office of Science User Facility operated for the U.S. Department of Energy Office of Science by Assonne National Laborators



Higher-level data types in Python

Python offers a number of data types that provide ways to form collections of other data types. Each of these have advantages for different types of programming

The three most basic higher-level data types in Python are <u>lists</u>, <u>tuples</u> and <u>dicts</u>.

 There are many other types of higher-level data types in Python that can be very useful, such as sets and datetime

Basics:

- lists and tuples are ordered collections of values,
- dictionaries (dicts) are unordered arrays of values with user supplied keys
- Lists, tuples, dicts can contain as values primitives (int, floats, etc.) or any higher-level data type (lists inside dicts inside tuples...)
- Lists, tuples and dictionaries all can play the role of arrays in Fortran or C.

Lets look in more detail, starting with the list data type



Outline of topics to be covered

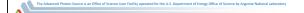
- 1. High-level data types
 - a) Lists
 - b) Tuples
 - c) Strings revisited
 - d) Dicts (dictionaries)
 - e) Sets
- 2. Length of a collection (len)

The Advanced Photon Source is an Office of Science User Facility operated for the U.S. Department of Energy Office of Science by Argonne National Laborator

Higher-level data types: Lists

A list contains a bunch of stuff in a specified order (Downey, Chapter 8)

- List:
 - a = [1,2,3,5,7,11]
- Elements in a list can be addressed individually:
 - print a[2]
 - 3 (Note: indexing starts with [0])
- List elements can be changed:
 - a[2] = -3 print a
 - [1, 2, -3, 5, 7, 11]
- A list can contain any other Python data type cvariable = complex(0,1)
 - B = [1, 3.14159, 'pi', ['a','list','in','a','list'], cvariable]





Slicing a list

The indices on a list can address a large number parts of the array in many ways using [start:end:increment]

>>> a = [1,2,3,5,7,11] >>> a [1, 2, 3, 5, 7, 11] >>> a[1:4] [2, 3, 5] >>> a[4:] [7, 11] >>> a[:4] [1, 2, 3, 5] >>> a[2:-1] [3, 5, 7] >>> a[2:-1]=[0,0,0] >>> print a [1, 2, 0, 0, 0, 11] >>> a[1::2] [2, 0, 11] >>> a[::2]=['a','b','c'] >>> a ['a', 2, 'b', 0, 'c', 11] >>> a[:] ['a', 2, 'b', 0, 'c', 11]

>>> a = [1,2,3,5,7,11,] >>> a[-3:-1] [5, 7] >>> a[-1:-3] [] >>> a[::-1] [11, 7, 5, 3, 2, 1] >>> a[-1:-3:-1] [11, 7]



Building a list

- A common way to use lists is to start with an empty list and add elements
 - A = []
 A.append(11)
 A.append(13)
- It is not possible to add elements by addressing past the end of the list:
 - IndexError: list assignment index out of range
- Like strings, lists can be added:

```
>>> [1,2,3] + [4,5,6]
[1, 2, 3, 4, 5, 6]
```



More fun things with lists

All Python data types are actually objects, with associated "methods". To see a list, use print dir(var); ignore items beginning with "_"

Method for lists: append, count, extend, index, insert, pop, remove, reverse, sort

```
>>> a
[1, 2, 3, 5, 7, 11]
>>> a.append(13)
>>> a
[1, 2, 3, 5, 7, 11, 13]
>>> a.insert(0,17)
>>> a
[17, 1, 2, 3, 5, 7, 11, 13]
>>> a.sort()
>>> a
[1, 2, 3, 5, 7, 11, 13]
```

```
>>> a = [1, 2, 3, 5, 7, 11, 13, 17]

>>> a.pop()

17

>>> a.pop(0)

1, 2, 3, 5, 7, 11, 13]

>>> a.pop(0)

1

>>> a.pop(0)

1

>>> a.pop(0)

1

>>> a.pop(0)

1

>>> a.pop(0)

6
```

The Advanced Photon Source is an Office of Science User Facility operated for the U.S. Department of Energy Office of Science by Argonne National Laborato

Higher-level data types: Tuples

Tuples (Downey, Chapter 9) are very similar to lists, but tuples cannot be changed (immutable)

- Tuples
 - Note that any time items are joined with a comma, a tuple is created, but this tends to be confusing; it is wise to always use parenthesis:

```
t = 1,2,3,5,7,11 #or
t = (1,2,3,5,7,11,) #or
t = (1,2,3,5,7,11)
```

• Elements in a tuple can be addressed individually just like a list:

```
print t[2]
```

- Note: indexing starts with [0], same as with a list
- Important distinction: Tuple elements *cannot* be changed:

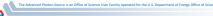
```
>>> t[2] = -3 TypeError: 'tuple' object does not support item assignment
```

Higher-level data types: Tuples

- A tuple can contain any other Python data type cvariable = complex(0,1)
 B = (1, 3.14159, 'pi', ['a','list','in','a','tuple'], cvariable)
- One can define an empty tuple: t = ()
 - One can't add to it
- To define a tuple with one element, the "extra" comma is required t = (1,)
- Tuples can be added as well

```
>>> (1,2,3) + (4,5,6)
(1, 2, 3, 4, 5, 6)
```

 Note that adding two tuples creates a third distinct tuple but does not change the original ones



Reprise: Strings

- Strings can be indexed just like lists and tuples
- Strings cannot be changed -- like tuples (but unlike lists)

```
>>> abc = 'abcdefghijklmnopqrstuvwxyz'
>>> len(abc)
26
>>> abc[1]
'b'
>>> abc[::-2]
'zxvtrpnljhfdb'
>>> abc[1] = 'B'
TypeError: 'str' object does not support item assignment
>>>
```



Quick Review: Tuples vs. Lists

- Tuples optionally use parenthesis () and cannot be changed
- Lists always use square brackets [] and can be modified in place
- They are different data types. You can't add a tuple and a list:

```
>>> (1,2,3) + [4,5,6]
TypeError: can only concatenate tuple (not "list") to tuple
```

The Advanced Photon Source is an Office of Science User Facility operated for the U.S. Department of Energy Office of Science by Argonne National Laboratory

Python Dictionaries

- A Python dictionary (type dict) a place where any number of data items can be stored, associated with a key (think of the key as a label that identifies each storage location). Unlike a list or tuple, where items are stored and retrieved sequentially, there is no order associated with elements in a dict.
- For some uses a dict is very much like an array
- Dicts can be defined by adding elements or all at one time (or both). The two
 examples below define the same dictionary:

```
A = {}
A[1] = 1.0
A[2] = 2.0
A['two'] = 2
A[2.1] = 2
```

```
A = { 1:1.0,
2: 2.0,
'two': 2,
2.1: 2,
}
```

```
>>> A
{1: 1.0, 2: 2.0, 2.1000000000001: 2, 'two': 2}
>>> A[2.1]
2
>>> A[2]
```



Methods for dicts

The routines associated with a dict are: clear, copy, fromkeys, get, has_key, items, iteritems, iterkeys, itervalues, keys, pop, popitem, setdefault, update, values

Most commonly used:

```
>>> A = {1:1.0, 2: 2.0, 'two': 2, 2.1: 2}
keys() gives a list of keys
                                    >>> A.keys()
                                    [1, 2, 2.100000000000001, 'two']
values() gives a list of values in the
                                    >>> A.values()
                                    [1.0, 2.0, 2, 2]
  same order as keys()
                                    >>> A.items()
                                    [(1, 1.0), (2, 2.0), ...
items() gives the dict contents as key,
                                    >>> A.has_key(2)
  value pairs
                                    True
                                    >>> A.has_key(2.2)
has_key(key) is True if the key is
                                    False
  defined
                                    >>> A.get(2,'not specified')
                                    2.0
                                    >>> A.get(2.2, 'not specified')
get(key) returns the value or None
                                    'not specified'
get(key,d) returns the value or d
```

The len() built-in

 Use len(var) to find out the number of elements in a list, tuple or dict or characters in a string

```
>>> A = []

>>> len(A)

0

>>> A = (1,2,3)

>>> len(A)

3

>>> A = {1:1.0, 2: 2.0, 'two':

2, 2.1: 2}

>>> len(A)

>>> len('test')

4
```

The Advanced Photon Source is an Office of Science User Facility operated for the U.S. Department of Energy Office of Science by Argonne National Laboratory

A newer Python data type: sets

 A set is similar to a list, except that it is unordered and only the unique elements are saved:

```
>>> set([3,2,1,0,1,2,3]) set([0, 1, 2, 3])
```

 Working with sets is a very nice way to perform logical manipulations of groups of items

```
>>> s1 = set([3,2,1,0,1,2,3])

>>> s2 = set((3,4,5))

>>> s2

set([3, 4, 5])

>>> s1 | s2 # union of sets

set([0, 1, 2, 3, 4, 5])

>>> len(s1 & s2) # count shared elements
```

Conversion back to a list is easy

```
>>> list( s1|s2 ) # union of sets as a list
[0, 1, 2, 3, 4, 5]
```

The Advanced Photon Source is an Office of Science User Facility operated for the U.S. Department of Energy Office of Science by Argonne National Labor

Homework

Specify the data types of the following values:

```
(1,2,3)
[2,3,4]
'To be, or not to be'
'To be', 'or not to be'
('To be', 'or not to be')
{2:3, 3:4}
[3,(1,2),4]
```

The Advanced Photon Source is an Office of Science User Facility operated for the U.S. Department of Energy Office of Science by Argonne National Laborator